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CURRENT STATUS OF THE IAU WORKING GROUP FOR NUMERICAL STANDARDS OF FUNDAMENTAL ASTRONOMY

B. LUZUM¹, N. CAPITAIN², A. FIENGA³, W. FOLKNER⁴, T. FUKUSHIMA⁵, J. HILTON¹,
C. HOHENKERK⁶, G. KRASINSKY⁷, G. PETIT⁸, E. PITJEVA⁷, M. SOFFEL⁹, P. WALLACE¹⁰

¹ U.S. Naval Observatory, USA

² Observatoire de Paris, France

³ Observatoire de Besancon, France

⁴ Jet Propulsion Laboratory, USA

⁵ National Astronomical Observatory, Japan

⁶ HM Nautical Almanac Office, UK

⁷ Institute of Applied Astronomy RAS, Russia

⁸ Bureau International des Poids et Mesures, France

⁹ Dresden Technical University, Germany

¹⁰ Rutherford Appleton Laboratory, UK

ABSTRACT. At the 2006 International Astronomical Union (IAU) General Assembly (GA), a proposal was adopted to form the Working Group (WG) for Numerical Standards of Fundamental Astronomy. The goal of the WG are to update “IAU Current Best Estimates” conforming with IAU Resolutions, the International Earth Rotation and Reference System Service (IERS) Conventions, and the Système International d’Unités (SI). Initial efforts have concentrated on determining which constants should be considered, the terminology regarding the description of the constants, and the dependence of the constant estimates on their associated models. The current status of WG activities and the anticipated future directions are presented.

1. INTRODUCTION

The IAU Working Group (WG) on Numerical Standards for Fundamental Astronomy has been tasked with updating the IAU Current Best Estimates (CBEs), conforming with the IAU Resolutions, IERS Conventions and Système International d’Unités whenever possible. As part of its effort to achieve this, the WG is working in close cooperation with IAU Commissions 4 and 52, the IERS, and the BIPM Consultative Committee for Units.

This is the third IAU WG to be tasked with producing CBEs and is adding to the legacy of the two previous WGs. The first Sub-group on Numerical Standards of the IAU WG on Astronomical Standards was headed by E.M. Standish and the WG report (Standish, 1995) established the rules which are still used today. For instance, this group decided on the two-tiered approach to the astronomical constants that we are currently using and also created the first CBEs for a list of IAU constants.

This work was continued by T. Fukushima and his IAU WG on Astronomical Standards (Fukushima, 2000; Fukushima, 2002). Many of the updates concerned work on constants in a general relativistic framework and improved estimates of the precession constant. This revised list of CBEs is the current IAU CBEs.

The excellent work of both these WGs has helped to establish the precedent and allows us to improve incrementally the values for which there are now better estimates.

2. CHANGES SINCE THE LAST CURRENT BEST ESTIMATES

In addition to the need to update the CBEs because of improved estimates, there have also been significant changes that impact the IAU CBEs. Since the IAU CBEs were adopted, the IERS Conventions 2003, a document widely used by the astronomical and geodetic communities, has been produced. This reference contains estimates of many of the constants included in the IAU CBEs.

One significant development was the adoption of a new precession model with IAU 2006 Resolution B1. This resolution accepted the conclusion of the IAU Division I Working Group on Precession and

the Ecliptic (Hilton *et al.*, 2006) and adopted the P03 precession theory of Capitaine *et al.* (2003). This resolution also replaced the terms lunisolar precession and planetary precession with precession of the equator and precession of the ecliptic. Another change is the redefinition of Barycentric Dynamical Time (TDB) that occurred with the adoption of IAU 2006 Resolution B3.

These resolutions fundamentally alter the status of the associated constants. For instance, the general precession found in the IAU CBEs is no longer the appropriate quantity to describe precession. It should be replaced with either the rate of precession of the equator in longitude (or of the Celestial Intermediate Pole), or a number of precession quantities or expressions. The resolutions also changed the status of the constant L_B to a defining constant.

3. CHANGES TO THE CURRENT BEST ESTIMATES

The current WG started where the previous IAU WG tasked with providing CBEs left off, by using the existing IAU CBEs as the starting draft. From this starting point, the WG has proceeded to update the CBEs based on internationally adopted values and recent research. Some examples are adopting values:

- from Committee on Data for Science and Technology (CODATA) 2006;
- suggested by the IAU Division I WG on Precession and the Ecliptic;
- based on recent research to modify most of the planetary masses and adding masses for Ceres, Pallas, Vesta, and Eris. These improvements are possible due to years of high-precision observations of spacecraft as they near planets and their satellites.

The interim CBEs chosen serve two significant purposes. First, they keep the IAU CBEs consistent, where possible, with international standards. They also keep the constants consistent with the most accurate estimates currently available, which is vital for enabling progress in research.

In summary, for the latest draft version, 6 additional constants have been added to that list, one constant has been superseded by another, and the numerical values for 10 additional constants have been replaced by more current values.

4. ADDITIONAL CONCERNS

In addition to updating the list of CBEs, the WG is beginning to address the larger issues surrounding the adoption of IAU CBEs. These include the mechanism to keep the CBEs current and the way in which these constants will be provided, the procedure to document the theoretical context of the constants, and whether the IAU should revise its current list of adopted constants to correspond with the new list of CBEs.

The mechanism for maintaining the IAU CBEs has been discussed and to date, three options have been considered. The current method is for the IAU to form a WG when it believes that the CBEs need to be updated. This method has worked in the past and there is no reason to believe that it would not work in the future. Another possibility would be to enlist the aid of the IERS Conventions Product Center to maintain the IAU CBEs. Since the IERS is an IAU service organization and it already has a mechanism in place to maintain CBEs, it is possible that the IERS Conventions could be used to maintain the IAU CBEs as well. The biggest problem with this method is that the user communities and the areas of research of the IERS and the IAU are slightly different and there is a possibility that these differences could be problematic. A third option is to create a permanent WG within IAU Commission 4 that would maintain the list of CBEs. One potential problem with this option is that in the past, the IAU has been reluctant to allow WGs to stand in perpetuity. More details will need to be obtained to determine the potential status of a WG either within an IAU Commission or Division.

When considering the way in which the CBEs will be provided, a few options have been suggested. The current method is to provide the CBEs with the maximum accuracy provided by the supporting scientific research. However, another option has been suggested to provide the CBEs with a decreased accuracy — essentially truncate the digits at the level where disagreement between estimates exists. This would allow for a longer shelf life for the constants. The obvious drawback to this method is that while these lower accuracy values may be sufficient for some users, they would not meet the needs of the users with the most stringent accuracy requirements. In order for this method to be viable, a list of the most

accurate constants would need to be easily accessible to the high-accuracy users. A third possibility would be to apply the decreased accuracy only to a potential list of constants to be submitted in the recommendations to the IAU for consideration as a new IAU System of Constants. This method has the advantage of keeping a list of constants with the highest possible accuracy (CBEs) while also creating a list of constants that will be more universally acceptable and have longer life (potentially new IAU System of Constants). The latter point is particularly apropos since the acceptance of any new System of Constants by the IAU General Assembly would be facilitated if the values to be adopted agreed (at least to the number of digits provided) with all reasonable research results and the longer life would be consistent with the long span between the adoption of new IAU Systems of Constants.

The numerical values for the CBEs are not numbers that exist in isolation; they are defined fully within the theoretical context in which they are estimated. The WG will need to account for this in the presentation of the CBEs by making the theoretical underpinnings apparent to the users of the CBEs. The level to which this is done and the method of achieving this are still under consideration.

Electronic information is likely to play an important role in achieving the proper level of documentation for the CBEs. The extent to which electronic information is used is also a topic that is still under consideration. Electronic media can either be used as a primary source for defining information or it can be used as a secondary source, providing supplemental information.

5. UPDATE OF IAU SYSTEM OF CONSTANTS

There are now significant differences between the CBEs and the current IAU system of constants. This is due to both increasing accuracy of estimates and to changes in astronomical theory. As a result of this, there appears to be a consensus to recommend to the 2009 IAU General Assembly that the IAU system of constants be updated. If this is to be accomplished, the WG will need to finalize the CBEs and be prepared to provide draft recommendations to the IAU by early 2009.

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